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(54) METHOD AND SYSTEM OF IDENTIFYING WIRELESS UNITS

VERFAHREN UND SYSTEM ZUR IDENTIFIKATION VON DRAHTLOSEN EINHEITEN

PROCEDE ET SYSTEME D'IDENTIFICATION D'UNITES SANS FIL

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Description**Technical Field**

5 [0001] This invention relates to communications protocols and to digital data communications. Still more particularly, the invention relates to data communications protocols in mediums such as radio communication or the like. The invention also relates to radio frequency identification devices for inventory control, object monitoring, determining the existence, location or movement of objects, or for remote automated payment.

Background Art

10 [0002] Communications protocols are used in various applications. For example, communications protocols can be used in electronic identification systems. As large numbers of objects are moved in inventory, product manufacturing, and merchandising operations, there is a continuous challenge to accurately monitor the location and flow of objects. Additionally, there is a continuing goal to interrogate the location of objects in an inexpensive and streamlined manner. One way of tracking objects is with an electronic identification system.

15 [0003] One presently available electronic identification system utilizes a magnetic coupling system. In some cases, an identification device may be provided with a unique identification code in order to distinguish between a number of different devices. Typically, the devices are entirely passive (have no power supply), which results in a small and portable package. However, such identification systems are only capable of operation over a relatively short range, limited by the size of a magnetic field used to supply power to the devices and to communicate with the devices.

20 [0004] Another wireless electronic identification system utilizes a large active transponder device affixed to an object to be monitored which receives a signal from an interrogator. The device receives the signal, then generates and transmits a responsive signal. The interrogation signal and the responsive signal are typically radio-frequency (RF) signals produced by an RF transmitter circuit. Because active devices have their own power sources, and do not need to be in close proximity to an interrogator or reader to receive power via magnetic coupling. Therefore, active transponder devices tend to be more suitable for applications requiring tracking of a tagged device that may not be in close proximity to an interrogator. For example, active transponder devices tend to be more suitable for inventory control or tracking.

25 [0005] Electronic identification systems can also be used for remote payment. For example, when a radio frequency identification device passes an interrogator at a toll booth, the toll booth can determine the identity of the radio frequency identification device, and thus of the owner of the device, and debit an account held by the owner for payment of toll or can receive a credit card number against which the toll can be charged. Similarly, remote payment is possible for a variety of other goods or services.

30 [0006] A communication system, such as a wireless identification system, typically includes two transponders: a commander station or interrogator, and a responder station or transponder device which replies to the interrogator.

35 [0007] If the interrogator has prior knowledge of the identification number of a device which the interrogator is looking for, it can specify that a response is requested only from the device with that identification number. Sometimes, such information is not available. For example, there are occasions where the interrogator is attempting to determine which of multiple devices are within communication range.

40 [0008] When the interrogator sends a message to a transponder device requesting a reply, there is a possibility that multiple transponder devices will attempt to respond simultaneously, causing a collision, and thus an erroneous message to be received by the interrogator. For example, if the interrogator sends out a command requesting that all devices within a communications range identify themselves, and gets a large number of simultaneous replies, the interrogator may not be able to interpret any of these replies. Thus, arbitration schemes are employed to permit communications free of collisions.

45 [0009] In one arbitration scheme or system, described in commonly assigned U.S. Patent Nos. 5,627,544; 5,583,850; 5,500,650; and 5,365,551, all to Snodgrass et al., the interrogator sends a command causing each device of a potentially large number of responding devices to select a random number from a known range and use it as that device's arbitration number. By transmitting requests for identification to various subsets of the full range of arbitration numbers, and checking for an error-free response, the interrogator determines the arbitration number of every responder station capable of communicating at the same time. Therefore, the interrogator is able to conduct subsequent uninterrupted communication with devices, one at a time, by addressing only one device.

50 [0010] Another arbitration scheme is referred to as the Aloha or slotted Aloha scheme. This scheme is discussed in various references relating to communications, such as Digital Communications: Fundamentals and Applications, Bernard Sklar, published January 1988 by Prentice Hall. In this type of scheme, a device will respond to an interrogator using one of many time domain slots selected randomly by the device. A problem with the Aloha scheme is that if there are many devices, or potentially many devices in the field (i.e. in communications range, capable of responding) then there must be many available slots or many collisions will occur. Having many available slots slows down replies. If the

magnitude of the number of devices in a field is unknown, then many slots are needed. This results in the system slowing down significantly because the reply time equals the number of slots multiplied by the time period required for one reply.

[0011] An electronic identification system which can be used as a radio frequency identification device, arbitration schemes, and various applications for such devices are described in detail in commonly assigned U. S. Patent Application Serial Number 08/705,043, filed August 29, 1996.

[0012] EP-779 520-A discloses a method of arbitrating between RFID devices by using a slotted Aloha scheme and an improvement in which a device responds in x out of y time slots.

Disclosure of the Invention

[0013] According to the present invention there is provided a method for wireless communication as defined in claim 1 and a system to enable wireless communication as defined in claim 27.

[0014] In embodiments of the invention a wireless identification device is configured to provide a signal to identify the device in response to an interrogation signal.

[0015] Embodiments of the invention may provide a method of establishing wireless communications between an interrogator and individual ones of multiple wireless identification devices. Tree search and Aloha methods are combined to establish communications between the interrogator and individual ones of the multiple wireless identification devices without collision.

[0016] Embodiments of the invention may provide a method of addressing messages from an interrogator to a selected one or more of a number of communications devices. A first predetermined number of bits are established to be used as unique identification numbers. Unique identification numbers respectively having the first predetermined number of bits are established for respective devices. A second predetermined number of bits are established to be used for random values. The devices are caused to select random values. Respective devices choose random values independently of random values selected by the other devices. The interrogator transmits a command requesting devices having random values within a specified group of random values to respond, the specified group being less than or equal to the entire set of random values. Devices receiving the command respectively determine if their chosen random values fall within the specified group and, if so, send a reply to the interrogator within a randomly selected time slot of a number of slots. If not, they do not send a reply. The interrogator determines if a collision occurred between devices that sent a reply and, if so, creates a new, smaller, specified group.

[0017] Embodiments of the invention may provide a communications system comprising an interrogator, and a plurality of wireless identification devices configured to communicate with the interrogator in a wireless fashion. The respective wireless identification devices have a unique identification number. The interrogator is configured to employ tree search and Aloha techniques to determine the unique identification numbers of the different wireless identification devices so as to be able to establish communications between the interrogator and individual ones of the multiple wireless identification devices without collision by multiple wireless identification devices attempting to respond to the interrogator at the same time.

[0018] Embodiments of the invention may provide a system comprising an interrogator configured to communicate to a selected one or more of a number of communications devices, and a plurality of communications devices. The devices are configured to select random values. Respective devices choose random values independently of random values selected by the other devices. The interrogator is configured to transmit a command requesting devices having random values within a specified group of random values to respond, the specified group being less than or equal to the entire set of random values. Devices receiving the command are configured to respectively determine if their chosen random values fall within the specified group and, if so, send a reply to the interrogator within a randomly selected time slot of a number of slots. If not, they do not send a reply. The interrogator is configured to determine if a collision occurred between devices that sent a reply and, if so, create a new, smaller, specified group.

[0019] Embodiments of the invention may include a radio frequency identification device comprising an integrated circuit including a receiver, a transmitter, and a microprocessor. In one embodiment, the integrated circuit is a monolithic single die single metal layer integrated circuit including the receiver, the transmitter, and the microprocessor. The device of this embodiment includes an active transponder, instead of a transponder which relies on magnetic coupling for power, and therefore has a much greater range.

Brief Description of the Drawings

[0020] Preferred embodiments of the invention are described below with reference to the following accompanying drawings.

Fig. 1 is a high level circuit schematic showing an interrogator and a radio frequency identification device embodying the invention.

Fig. 2 is a front view of a housing, in the form of a badge or card, supporting the circuit of Fig. 1 according to one embodiment the invention.

Fig. 3 is a front view of a housing supporting the circuit of Fig. 1 according to another embodiment of the invention.

Fig. 4 is a diagram illustrating a tree splitting sort method for establishing communication with a radio frequency identification device in a field of a plurality of such devices, without collisions.

Fig. 5 is a time line plot illustrating operation of a slotted Aloha scheme.

Fig 6..is a diagram illustrating using a combination of a tree splitting sort method with an Aloha method for establishing communication with a radio frequency identification device in a field of a plurality of such devices.

Best Modes for Carrying Out the Invention and Disclosure of Invention

[0021] Fig. 1 illustrates a wireless identification device 12 in accordance with one embodiment of the invention. In the illustrated embodiment, the wireless identification device is a radio frequency data communication device 12, and includes RFID circuitry 16. In the illustrated embodiment, the RFID circuitry is defined by an integrated circuit as described in the above-incorporated patent application 08/705,043, filed August 29, 1996. Other embodiments are possible. A power source 18 is connected to the integrated circuit 16 to supply power to the integrated circuit 16. In one embodiment, the power source 18 comprises a battery. The device 12 further includes at least one antenna 14 connected to the circuitry 16 for wireless or radio frequency transmission and reception by the circuitry 16.

[0022] The device 12 transmits and receives radio frequency communications to and from an interrogator 26. An exemplary interrogator is described in U.S. Patent Application Serial No. 08/907,689, filed August 8, 1997.

[0023] Preferably, the interrogator 26 includes an antenna 28, as well as dedicated transmitting and receiving circuitry, similar to that implemented on the integrated circuit 16.

[0024] Generally, the interrogator 26 transmits an interrogation signal or command 27 via the antenna 28. The device 12 receives the incoming interrogation signal via its antenna 14. Upon receiving the signal 27, the device 12 responds by generating and transmitting a responsive signal or reply 29. The responsive signal 29 typically includes information that uniquely identifies, or labels the particular device 12 that is transmitting, so as to identify any object or person with which the device 12 is associated.

[0025] Although only one device 12 is shown in Fig. 1, typically there will be multiple devices 12 that correspond with the interrogator 26, and the particular devices 12 that are in communication with the interrogator 26 will typically change over time. In the illustrated embodiment in Fig. 1, there is no communication between multiple devices 12. Instead, the devices 12 respectively communicate with the interrogator 26. Multiple devices 12 can be used in the same field of an interrogator 26 (i.e., within communications range of an interrogator 26). Similarly, multiple interrogators 26 can be in proximity to one or more of the devices 12.

[0026] The radio frequency data communication device 12 can be included in any appropriate housing or packaging. Various methods of manufacturing housings are described in commonly assigned U.S. Patent Application Serial No. 08/800,037, filed February 13, 1997.

[0027] Fig. 2 shows but one embodiment in the form of a card or badge 19 including the radio frequency data communication device 12, and a housing 11 including plastic or other suitable material. In one embodiment, the front face of the badge has visual identification features such as graphics, text, information found on identification or credit cards, etc.

[0028] Fig. 3 illustrates but one alternative housing supporting the device 12. More particularly, Fig. 3 shows a miniature housing 20 encasing the device 12 to define a tag which can be supported by an object (e.g., hung from an object, affixed to an object, etc.). Although two particular types of housings have been disclosed, the device 12 can be included in any appropriate housing.

[0029] If the power source 18 is a battery, the battery can take any suitable form. Preferably, the battery type will be selected depending on weight, size, and life requirements for a particular application. In one embodiment, the battery 18 is a thin profile or button-type cell forming a small, thin energy cell more commonly utilized in watches and small electronic devices requiring a thin profile. A conventional cell has a pair of electrodes, an anode formed by one face and a cathode formed by an opposite face. In an alternative embodiment, the power source 18 comprises a series connected pair of cells. Instead of using a battery, any suitable power source can be employed.

[0030] The circuitry 16 further includes a backscatter transmitter and is configured to provide a responsive signal to the interrogator 26 by radio frequency. More particularly, the circuitry 16 includes a transmitter, a receiver, and memory such as is described in U.S. Patent Application Serial Number 08/705,043.

[0031] Radio frequency identification has emerged as a viable and affordable alternative to tagging or labeling small to large quantities of items. The interrogator 26 communicates with the devices 12 via an RF link, so all transmissions by the interrogator 26 are heard simultaneously by all devices 12 within range.

[0032] If the interrogator 26 sends out a command requesting that all devices 12 within range identify themselves, and gets a large number of simultaneous replies, the interrogator 26 may not be able to interpret any of these replies. Therefore, arbitration schemes are provided.

[0033] If the interrogator 26 has prior knowledge of the identification number of a device 12 which the interrogator 26 is looking for, it can specify that a response is requested only from the device 12 with that identification number. To target a command at a specific device 12, (i.e., to initiate point-on-point communication), the interrogator 26 must send a number identifying a specific device 12 along with the command. At start-up, or in a new or changing environment, these identification numbers are not known by the interrogator 26. Therefore, the interrogator 26 must identify all devices 12 in the field (within communication range) such as by determining the identification numbers of the devices 12 in the field. After this is accomplished, point-to-point communication can proceed as desired by the interrogator 26.

[0034] Generally speaking, RFID systems are a type of multiaccess communication system. The distance between the interrogator 26 and devices 12 within the field is typically fairly short (e.g., several meters), so packet transmission time is determined primarily by packet size and baud rate. Propagation delays are negligible. In RFID systems, there is a potential for a large number of transmitting devices 12 and there is a need for the interrogator 26 to work in a changing environment, where different devices 12 are swapped in and out frequently (e.g., as inventory is added or removed). The inventors have determined that, in such systems, the use of random access methods work effectively for contention resolution (i.e., for dealing with collisions between devices 12 attempting to respond to the interrogator 26 at the same time).

[0035] RFID systems have some characteristics that are different from other communications systems. For example, one characteristic of the illustrated RFID systems is that the devices 12 never communicate without being prompted by the interrogator 26. This is in contrast to typical multiaccess systems where the transmitting units operate more independently. In addition, contention for the communication medium is short lived as compared to the ongoing nature of the problem in other multiaccess systems. For example, in a RFID system, after the devices 12 have been identified, the interrogator can communicate with them in a point-to-point fashion. Thus, arbitration in a RFID system is a transient rather than steady-state phenomenon. Further, the capability of a device 12 is limited by practical restrictions on size, power, and cost. The lifetime of a device 12 can often be measured in terms of number of transmissions before battery power is lost. Therefore, one of the most important measures of system performance in RFID arbitration is total time required to arbitrate a set of devices 12. Another measure is power consumed by the devices 12 during the process. This is in contrast to the measures of throughput and packet delay in other types of multiaccess systems.

[0036] Fig. 4 illustrates one arbitration scheme that can be employed for communication between the interrogator and devices 12. Although the arbitration system is being described in connection with a wireless identification system or RFID system, this and other arbitration schemes disclosed herein can be employed in any communication system. Generally, the interrogator 26 sends a command causing each device 12 of a potentially large number of responding devices 12 to select a random number from a known range and use it as that device's arbitration number. By transmitting requests for identification to various subsets of the full range of arbitration numbers, and checking for an error-free response, the interrogator 26 determines the arbitration number of every responder station capable of communicating at the same time. Therefore, the interrogator 26 is able to conduct subsequent uninterrupted communication with devices 12, one at a time, by addressing only one device 12.

[0037] Three variables are used: an arbitration value (AVALUE), an arbitration mask (AMASK), and a random value ID (RV). The interrogator sends a command causing each device of a potentially large number of responding devices to select a random number from a known range and use it as that device's arbitration number. The interrogator sends an arbitration value (AVALUE) and an arbitration mask (AMASK) to a set of devices 12. The receiving devices 12 evaluate the following equation: $(AMASK \& AVALUE) == (AMASK \& RV)$ wherein "&" is a bitwise AND function, and wherein "==" is an equality function. If the equation evaluates to "1" (TRUE), then the device 12 will reply. If the equation evaluates to "0" (FALSE), then the device 12 will not reply. By performing this in a structured manner, with the number of bits in the arbitration mask being increased by one each time, eventually a device 12 will respond with no collisions. Thus, a binary search tree methodology is employed.

[0038] An example using actual numbers will now be provided using only four bits, for simplicity, reference being made to Fig. 4. In one embodiment, sixteen bits are used for AVALUE and AMASK, respectively. Other numbers of bits can also be employed depending, for example, on the number of devices 12 expected to be encountered in a particular application, on desired cost points, etc.

[0039] Assume, for this example, that there are two devices 12 in the field, one with a random value (RV) of 1100 (binary), and another with a random value (RV) of 1010 (binary). The interrogator is trying to establish communications without collisions being caused by the two devices 12 attempting to communicate at the same time.

[0040] The interrogator sets AVALUE to 0000 (or all "don't care", indicated by the character "X" in Fig. 4) and AMASK to 0000. The interrogator transmits a command to all devices 12 requesting that they identify themselves. Each of the devices 12 evaluate $(AMASK \& AVALUE) == (AMASK \& RV)$ using the random value RV that the respective devices 12 selected. If the equation evaluates to "1" (TRUE), then the device 12 will reply. If the equation evaluates to "0" (FALSE), then the device 12 will not reply. In the first level of the illustrated tree, AMASK is 0000 and anything bitwise ANDed with all zeros results in all zeros, so both the devices 12 in the field respond, and there is a collision.

[0041] Next, the interrogator sets AMASK to 0001 and AVALUE to 0000 and transmits an identify command. Both

devices 12 in the field have a zero for their least significant bit, and $(AMASK \& AVALUE) == (AMASK \& RV)$ will be true for both devices 12. For the device 12 with a random value of 1100, the left side of the equation is evaluated as follows $(0001 \& 0000) = 0000$. The right side is evaluated as $(0001 \& 1100) = 0000$. The left side equals the right side, so the equation is true for the device 12 with the random value of 1100. For the device 12 with a random value of 1010, the left side of the equation is evaluated as $(0001 \& 0000) = 0000$. The right side is evaluated as $(0001 \& 1010) = 0000$. The left side equals the right side, so the equation is true for the device 12 with the random value of 1010. Because the equation is true for both devices 12 in the field, both devices 12 in the field respond, and there is another collision.

[0042] Recursively, the interrogator next sets AMASK to 0011 with AVALUE still at 0000 and transmits an identify command. $(AMASK \& AVALUE) == (AMASK \& RV)$ is evaluated for both devices 12. For the device 12 with a random value of 1100, the left side of the equation is evaluated as follows $(0011 \& 0000) = 0000$. The right side is evaluated as $(0011 \& 1100) = 0000$. The left side equals the right side, so the equation is true for the device 12 with the random value of 1100, so this device 12 responds. For the device 12 with a random value of 1010, the left side of the equation is evaluated as $(0011 \& 0000) = 0000$. The right side is evaluated as $(0011 \& 1010) = 0010$. The left side does not equal the right side, so the equation is false for the device 12 with the random value of 1010, and this device 12 does not respond. Therefore, there is no collision, and the interrogator can determine the identity (e.g., an identification number) for the device 12 that does respond.

[0043] De-recursion takes place, and the devices 12 to the right for the same AMASK level are accessed by setting AVALUE at 0010 and using the same AMASK value 0011.

[0044] The device 12 with the random value of 1010 receives a command and evaluates the equation $(AMASK \& AVALUE) == (AMASK \& RV)$. The left side of the equation is evaluated as $(0011 \& 0010) = 0010$. The right side of the equation is evaluated as $(0011 \& 1010) = 0010$. The right side equals the left side, so the equation is true for the device 12 with the random value of 1010. Because there are no other devices 12 in the subtree, a good reply is returned by the device 12 with the random value of 1010. There is no collision, and the interrogator can determine the identity (e.g., an identification number) for the device 12 that does respond.

[0045] By recursion, what is meant is that a function makes a call to itself. In other words, the function calls itself within the body of the function. After the called function returns, de-recursion takes place and execution continues at the place just after the function call; i.e. at the beginning of the statement after the function call.

[0046] For instance, consider a function that has four statements (numbered 1,2,3,4) in it, and the second statement is a recursive call. Assume that the fourth statement is a return statement. The first time through the loop (iteration 1) the function executes the statement 2 and (because it is a recursive call) calls itself causing iteration 2 to occur. When iteration 2 gets to statement 2, it calls itself making iteration 3. During execution in iteration 3 of statement 1, assume that the function does a return. The information that was saved on the stack from iteration 2 is loaded and the function resumes execution at statement 3 (in iteration 2), followed by the execution of statement 4 which is also a return statement. Since there are no more statements in the function, the function de-recurses to iteration 1. Iteration 1, had previously recursively called itself in statement 2. Therefore, it now executes statement 3 (in iteration 1). Following that it executes a return at statement 4. Recursion is known in the art.

[0047] Consider the following code, which employs recursion, and which can be used to implement operation of the method shown in Fig. 4 and described above.

```

40 Arbitrate(AMASK, AVALUE)
    {
        collision = IdentifyCmdnd(AMASK, AVALUE)
        if (collision) then
            {
45         /* recursive call for left side */
            Arbitrate((AMASK<<1)+1, AVALUE)
            /* recursive call for right side */
            Arbitrate((AMASK<<1)+1, AVALUE+(AMASK+1))
            } /* endif */
        } /* return */
50

```

[0048] The symbol "<<" represents a bitwise left shift. "<< 1" means shift left by one place. Thus, $0001 \ll 1$ would be 0010. Note, however, that AMASK is originally called with a value of zero, and $0000 \ll 1$ is still 0000. Therefore, for the first recursive call, $AMASK = (AMASK \ll 1) + 1$. So for the first recursive call, the value of AMASK is $0000 + 0001 = 0001$. For the second call, $AMASK = (0001 \ll 1) + 1 = 0010 + 1 = 0011$. For the third recursive call, $AMASK = (0011 \ll 1) + 1 = 0110 + 1 = 0111$.

[0049] The routine generates values for AMASK and AVALUE to be used by the interrogator in an identify command "IdentifyCmdnd." Note that the routine calls itself if there is a collision. De-recursion occurs when there is no collision.

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AVALUE and AMASK would have values such as the following assuming there are collisions all the way down to the bottom of the tree.

A VALUE	AMASK
0000	0000
0000	0001
0000	0011
0000	0111
0000	1111*
1000	1111*
0100	0111
0100	1111*
1100	1111*

[0050] This sequence of AMASK, AVALUE binary numbers assumes that there are collisions all the way down to the bottom of the tree, at which point the Identify command sent by the interrogator is finally successful so that no collision occurs. Rows in the table for which the interrogator is successful in receiving a reply without collision are marked with the symbol "*". Note that if the Identify command was successful at, for example, the third line in the table then the interrogator would stop going down that branch of the tree and start down another, so the sequence would be as shown in the following table.

AVALUE	AMASK
0000	0000
0000	0001
0000	0011*
0010	0011
...	...

[0051] This method is referred to as a splitting method. It works by splitting groups of colliding devices 12 into subsets that are resolved in turn. The splitting method can also be viewed as a type of tree search. Each split moves the method one level deeper in the tree. Either depth-first or breadth first traversals of the tree can be employed.

[0052] Another arbitration method that can be employed is referred to as the "Aloha" method. In the Aloha method, every time a device 12 is involved in a collision, it waits a random period of time before retransmitting. This method can be improved by dividing time into equally sized slots and forcing transmissions to be aligned with one of these slots. This is referred to as "slotted Aloha." In operation, the interrogator asks all devices 12 in the field to transmit their identification numbers in the next time slot. If the response is garbled, the interrogator informs the devices 12 that a collision has occurred, and the slotted Aloha scheme is put into action. This means that each device 12 in the field responds within an arbitrary slot determined by a randomly selected value. In other words, in each successive time slot, the devices 12 decide to transmit their identification number with a certain probability.

[0053] The Aloha method is based on a system operated by the University of Hawaii. In 1971, the University of Hawaii began operation of a system named Aloha. A communication satellite was used to interconnect several university computers by use of a random access protocol. The system operates as follows. Users or devices transmit at any time they desire. After transmitting, a user listens for an acknowledgment from the receiver or interrogator. Transmissions from different users will sometimes overlap in time (collide), causing reception errors in the data in each of the contending messages. The errors are detected by the receiver, and the receiver sends a negative acknowledgment to the users. When a negative acknowledgment is received, the messages are retransmitted by the colliding users after a random delay. If the colliding users attempted to retransmit without the random delay, they would collide again. If the user does not receive either an acknowledgment or a negative acknowledgment within a certain amount of time, the user "times out" and retransmits the message.

[0054] In the slotted Aloha scheme, a sequence of coordination pulses is broadcast to all stations (devices). As is the

case with the pure Aloha scheme, packet lengths are constant. Messages are required to be sent in a slot time between synchronization pulses, and can be started only at the beginning of a time slot. This reduces the rate of collisions because only messages transmitted in the same slot can interfere with one another. The retransmission mode of the pure Aloha scheme is modified for slotted Aloha such that if a negative acknowledgment occurs, the device retransmits after a random delay of an integer number of slot times.

[0055] Fig. 5 illustrates operation of the slotted Aloha scheme. Fig. 5 shows a packet of data bits transmitted by a first device 12a, which is substantially identical to the device 12. The interrogator 26 acknowledges receipt without collision, as indicated in Fig. 5 by the symbol ACK. Fig. 5 also shows devices 12b and 12c, also substantially identical to the device 12, simultaneously transmitting packets of data to the interrogator 26, resulting in a collision. The interrogator returns a negative acknowledgment, as indicated in Fig. 5 by the symbol NAK. The devices 12b and 12c then respectively select random numbers, and retransmit after a time delay corresponding to the selected random number. There is a possibility that the devices 12b and 12c will again transmit at the same times, causing another collision, but in that case they will retransmit again using newly selected random numbers until there is no collision.

[0056] Another form of Aloha scheme is called reservation-Aloha. The reservation-Aloha system has two basic modes: an unreserved mode, and a reserved mode.

[0057] In the unreserved mode, a time frame is established and divided into a number of small reservation subslots. Users (devices) use these subslots to reserve message slots. After requesting a reservation, the user (device) listens for an acknowledgment and a slot assignment.

[0058] In the reserved mode, a time frame is divided into a certain number of slots whenever a reservation is made. All but the last slot are used for message transmissions. The last slot is subdivided into subslots to be used for reservations. Users (devices) send message packets in their assigned portions of the slots reserved for message transmissions.

[0059] Fig. 6 illustrates combining a tree sort method of a type such as the one shown in Fig. 4 with an Aloha method. Combining the two methods allows a minimal number of slots to be used and takes advantage of the conquer and divide approach of the tree sort method. The method shown in Fig. 6 proceeds in a manner similar to the manner described in connection with Fig. 4, except that devices 12 in the field that reply for the given AMASK and AVALUE, reply within a randomly selected time slot. This significantly reduces the number of collisions. In one embodiment, the reply includes the unique identification number of the particular device 12. In one embodiment, the reply includes the random value RV selected by the particular device 12. In one embodiment, the reply includes both the unique identification number of the particular device 12 as well as the random value RV selected by the same device 12.

[0060] In one embodiment, the same randomly selected time slot is used by a device 12 at different levels of the tree (i.e., for different values of AMASK and AVALUE). In another embodiment, different randomly selected times slots are used by a device 12 at different levels of the tree (i.e., for different values of AMASK and AVALUE). In one embodiment, a combination of these approaches is used. For example, one embodiment utilizes a method where the interrogator goes down the tree until some responses without collision are received, before the devices 12 re-randomize their Aloha random number. This can be classified as an adaptive method. Other adaptive methods are possible. For example, in one embodiment, the number of Aloha slots is reduced at lower levels of the tree. The number of slots can be reduced by the same number for each level down the tree, or by a number that varies depending on the number of levels down the tree. Thus, for example, the number of slots can remain constant through a progression down the tree until some responses without collision are received, at which point the number of slots is reduced.

[0061] Thus, this embodiment provides the advantages of both the Aloha methods and the tree sorting methods of establishing communications without collisions.

[0062] In another embodiment, levels of the search tree are skipped. Skipping levels in the tree, after a collision caused by multiple devices 12. responding, reduces the number of subsequent collisions without adding significantly to the number of no replies. In real-time systems, it is desirable to have quick arbitration sessions on a set of devices 12 whose unique identification numbers are unknown. Level skipping reduces the number of collisions, both reducing arbitration time and conserving battery life on a set of devices 12. In one embodiment, every other level is skipped. In alternative embodiments, more than one level is skipped each time.

[0063] The trade off that must be considered in determining how many (if any) levels to skip with each decent down the tree is as follows. Skipping levels reduces the number of collisions, thus saving battery power in the devices 12. Skipping deeper (skipping more than one level) further reduces the number of collisions. The more levels that are skipped, the greater the reduction in collisions. However, skipping levels results in longer search times because the number of queries (Identify commands) increases. The more levels that are skipped, the longer the search times. Skipping just one level has an almost negligible effect on search time, but drastically reduces the number of collisions. If more than one level is skipped, search time increases substantially. Skipping every other level drastically reduces the number of collisions and saves battery power without significantly increasing the number of queries.

[0064] Level skipping methods are described in a commonly assigned patent application (attorney docket MI40-117) naming Clifton W. Wood, Jr. and Don Hush as inventors, titled "Method of Addressing Messages, Method of Establishing Wireless Communications, and Communications System," filed concurrently herewith.

Claims

1. A method for wireless communication between an interrogator (26) and at least one radio frequency identification device (12) to identify the radio frequency identification device (12) in an environment containing multiple radio frequency identification devices, comprising:

providing the at least one device (12), wherein the at least one device (12) is configured to generate a random value for use in an arbitration scheme;
 sending a first command from the interrogator (26) to the at least one device (12), the first command comprising a set of bits, at least one of said bits indicating that the at least one device is selected to participate in said arbitration scheme; and **characterised by**
 utilizing, as part of said arbitration scheme, a randomly selected one of a first number of slots to at least partly determine when said at least one device (12) can communicate a first reply to said first command;
 sending a second command from the interrogator (26) to the at least one device (12);
 utilizing, as part of said arbitration scheme, a randomly selected one of a second number of slots to at least partly determine when said at least one device can communicate a second reply to said second command, said second number of slots being different than said first number of slots; and
 communicating the second reply from the at least one device (12) to the interrogator (26), the second reply comprising said random value generated by the device (12).

2. The method of claim 1, further comprising:

communicating said first reply from said at least one device (12); and
 determining that said first reply collides with another communication; wherein said second command is sent in response to said act of determining.

3. The method of claim 1, wherein said second number of slots is less than said first number of slots.

4. The method of claim 3, further comprising:

issuing from said at least one device (12) said first reply;
 detecting, using at least said interrogator (26), when a collision between said first reply and another communication has occurred; and
 determining said second number of slots based at least in part on said detecting.

5. The method of claim 4, further comprising the at least one device (12) backscattering at least a portion of an identification code that uniquely identifies an object to which the at least one device (12) is affixed.

6. The method of claim 1, wherein said random value comprises a 16 bit random number.

7. The method of claim 1, wherein said at least one device (12) chooses said random value independently of random values selected by other devices communicating with said interrogator (26).

8. The method of claim 1, wherein said method further comprises communicating the first reply from the at least one device (12) to the interrogator (26), the first reply comprising a unique identification value associated with the at least one device (12).

9. The method of claim 1, further comprising sending a signal from the interrogator (26) to the at least one device (12) in response to receiving the second reply.

10. The method of claim 9, wherein said signal comprises an acknowledgement to the second reply.

11. The method of claim 1, wherein the second reply is received by the interrogator (26) without detecting a collision.

12. The method of claim 1, wherein said second command is issued by said interrogator (26) substantially in response to said interrogator determining that a collision occurred between said first reply and a communication of another device.

13. The method of claim 1, wherein said utilizing a randomly selected one of a first number of slots to at least partly determine when said at least one device (12) can communicate a first reply comprises picking said randomly selected one of said first number of slots in response to said first command.
14. The method of claim 13, wherein said utilizing a randomly selected one of a second number of slots to at least partly determine when said at least one device (12) can communicate a second reply comprises picking said randomly selected one of said second number of slots in response to said second command.
15. The method of claim 14, wherein the at least one device (12) comprises a passive radio frequency identification (RFID) device (12) adapted to backscatter energy transmitted from said interrogation apparatus, and further adapted to be affixed to an object.
16. The method of claim 1, wherein said at least one device (12) comprises a plurality of radio frequency identification tags, and said arbitration scheme relates the occurrence of communication collisions between ones of said tags and said second number of slots.
17. The method of claim 1, wherein said first command comprises a command requesting a plurality of devices including said at least one device (12) to identify themselves via said first reply.
18. The method of claim 1, wherein said at least one of said bits indicates to the at least one device (12) that it is a device within a specified group for participation in said arbitration scheme.
19. The method of claim 1, further comprising the at least one device (12) determining, based on at least one bit of the second command, if the at least one device (12) is a participant that may respond to the second command.
20. The method of claim 1 or claim 19, further comprising the at least one device (12) backscattering of an identification code for use in uniquely identifying an object to which the device (12) is affixed.
21. The method of claim 1 or claim 19, further comprising the at least one device (12) backscattering of an identification code for use in uniquely identifying said at least one device (12), and hence an object to which the at least one device (12) is affixed.
22. The method of claim 1, further comprising the interrogator (26) transmitting the random value back to the at least one device (12) to individually access the at least one device (12).
23. The method of claim 22, further comprising the at least one device (12) backscattering of an identification code that can be used to uniquely identify said at least one device (12) or an object to which the at least one device (12) is affixed.
24. The method of claim 1, wherein the at least one device (12) is capable of backscattering energy generated by said interrogator (26) and including in said backscattered energy information uniquely identifying said device (12), and said method further comprises affixing said device (12) to an object.
25. The method of claim 1, wherein said interrogator (26) further transmits a command comprising a mask, said mask comprising a bit string said bit string being used by said at least one device (12) to determine whether said tag is selected for further communication.
26. The method of any of the preceding claims, wherein said arbitration scheme comprises an adaptive slotted random anti-collision scheme, wherein said adaptation comprises selecting the second number of slots to be different from the first number of slots.
27. A system to enable wireless communication between electronic devices and to identify at least one of the devices in an environment containing multiple devices, comprising:

an interrogator (26) comprising circuitry adapted for radio frequency transmission and reception, and an antenna (28) in signal communication with said circuitry; and at least one radio frequency identification device (12);
characterised in that said interrogator (26) and said at least one radio frequency device (12) are adapted to communicate in accordance with the method of any of the preceding claims.

28. The system of claim 27, wherein said at least one device (12) comprises a passive radio frequency identification device (12) comprising an integrated circuit (16) and an antenna (14) in signal communication with said integrated circuit, said device (12) further comprising a backscatter transmitter for backscattering energy emitted by said interrogator (26).

29. The system of claim 28, wherein said at least one device (12) comprises a planar form and is formed at least partly from a plastic, and is configured to be affixed to an object.

Patentansprüche

1. Verfahren für drahtlose Kommunikation zwischen einer Abfragevorrichtung (26) und mindestens einer Funkfrequenzidentifikations-Vorrichtung (12), um die Funkfrequenzidentifikations-Vorrichtung (12) in einer Umgebung, die mehrere Funkfrequenzidentifikations-Vorrichtungen enthält, zu identifizieren, umfassend:

Bereitstellen der mindestens einen Vorrichtung (12), wobei die mindestens eine Vorrichtung (12) konfiguriert ist, um einen Zufallswert zur Verwendung in einem Arbitrierungsschema zu erzeugen;

Senden eines ersten Befehls von der Abfragevorrichtung (26) zu der mindestens einen Vorrichtung (12), wobei der erste Befehl einen Satz von Bits umfasst, wobei mindestens eines der Bits anzeigt, dass die mindestens eine Vorrichtung ausgewählt wurde, um an dem Arbitrierungsschema teilzunehmen; und **gekennzeichnet durch**

Nutzen, als Teil des Arbitrierungsschemas, eines zufällig ausgewählten einen ersten Zahl von Schlitten, um zumindest teilweise zu bestimmen, wann die mindestens eine Vorrichtung (12) eine erste Antwort auf den ersten Befehl kommunizieren kann;

Senden eines zweiten Befehls von der Abfragevorrichtung (26) zu der mindestens einen Vorrichtung (12); Nutzen, als Teil des Arbitrierungsschemas, eines zufällig ausgewählten einen zweiten Zahl von Schlitten, um zumindest teilweise zu bestimmen, wann die mindestens eine Vorrichtung eine zweite Antwort auf den zweiten Befehl kommunizieren kann, wobei die zweite Zahl von Schlitten von der ersten Zahl von Schlitten verschieden ist; und

Kommunizieren der zweiten Antwort von der mindestens einen Vorrichtung (12) zu der Abfragevorrichtung (26), wobei die zweite Antwort den von der Vorrichtung (12) erzeugten Zufallswert umfasst.

2. Verfahren nach Anspruch 1, weiter umfassend:

Kommunizieren der ersten Antwort von der mindestens einen Vorrichtung (12); und Bestimmen, dass die erste Antwort mit einer anderen Kommunikation kollidiert; wobei der zweite Befehl als Reaktion auf die Handlung der Bestimmung gesandt wird.

3. Verfahren nach Anspruch 1, wobei die zweite Zahl von Schlitten kleiner als die erste Zahl von Schlitten ist.

4. Verfahren nach Anspruch 3, weiter umfassend:

Ausgeben der ersten Antwort von der mindestens einen Vorrichtung (12); Erfassen unter Verwendung von mindestens der Abfragevorrichtung (26), wann eine Kollision zwischen der ersten Antwort und einer anderen Kommunikation stattgefunden hat; und Bestimmen der zweiten Zahl von Schlitten zumindest teilweise basierend auf der Erfassung.

5. Verfahren nach Anspruch 4, weiter umfassend, dass die mindestens eine Vorrichtung (12) zumindest einen Teil eines Identifikationscodes rückstreut, der eindeutig ein Objekt identifiziert, an dem die mindestens eine Vorrichtung (12) befestigt ist.

6. Verfahren nach Anspruch 1, wobei der Zufallswert eine 16-Bit-Zufallszahl umfasst.

7. Verfahren nach Anspruch 1, wobei die mindestens eine Vorrichtung (12) den Zufallswert unabhängig von Zufallswerten auswählt, die von anderen Vorrichtungen, die mit der Abfragevorrichtung (26) kommunizieren, ausgewählt wurden.

8. Verfahren nach Anspruch 1, wobei das Verfahren weiter umfasst, die erste Antwort von der mindestens einen

Vorrichtung (12) zu der Abfragevorrichtung (26) zu kommunizieren, wobei die erste Antwort einen eindeutigen Identifikationswert umfasst, der mit der mindestens einen Vorrichtung (12) assoziiert ist.

9. Verfahren nach Anspruch 1, weiter umfassend, ein Signal von der Abfragevorrichtung (26) zu der mindestens einen Vorrichtung (12) als Reaktion auf den Empfang der zweiten Antwort zu senden.

10. Verfahren nach Anspruch 9, wobei das Signal eine Bestätigung der zweiten Antwort umfasst.

11. Verfahren nach Anspruch 1, wobei die zweite Antwort von der Abfragevorrichtung (26) ohne Erfassen einer Kollision empfangen wird.

12. Verfahren nach Anspruch 1, wobei der zweite Befehl von der Abfragevorrichtung (26) im Wesentlichen als Reaktion darauf ausgegeben wird, dass die Abfragevorrichtung bestimmt, dass eine Kollision zwischen der ersten Antwort und einer Kommunikation einer anderen Vorrichtung stattgefunden hat.

13. Verfahren nach Anspruch 1, wobei die Nutzung eines zufällig ausgewählten einen der ersten Zahl von Schlitzten, um zumindest teilweise zu bestimmen, wann die mindestens eine Vorrichtung (12) eine erste Antwort kommunizieren kann, umfasst, den zufällig ausgewählten einen der ersten Zahl von Schlitzten als Reaktion auf den ersten Befehl zu wählen.

14. Verfahren nach Anspruch 13, wobei die Nutzung eines zufällig ausgewählten einen der zweiten Zahl von Schlitzten, um zumindest teilweise zu bestimmen, wann die mindestens eine Vorrichtung (12) eine zweite Antwort kommunizieren kann, umfasst, den zufällig ausgewählten einen der zweiten Zahl von Schlitzten als Reaktion auf den zweiten Befehl zu wählen.

15. Verfahren nach Anspruch 14, wobei die mindestens eine Vorrichtung (12) eine passive Funkfrequenzidentifikations-(RFID)-Vorrichtung (12) umfasst, die angepasst ist, um Energie rückzustreuen, die von der Abfragevorrichtung übertragen wurde, und weiter angepasst ist, um an ein Objekt befestigt zu werden.

16. Verfahren nach Anspruch 1, wobei die mindestens eine Vorrichtung (12) eine Vielzahl von Funkfrequenzidentifikations-Markierungen umfasst und das Arbitrierungsschema das Stattfinden von Kommunikationskollisionen zwischen einen der Markierungen und der zweiten Zahl von Schlitzten in Beziehung setzt.

17. Verfahren nach Anspruch 1, wobei der erste Befehl einen Befehl umfasst, der eine Vielzahl von Vorrichtungen einschließlich der mindestens einen Vorrichtung (12) auffordert, sich selbst über die erste Antwort zu identifizieren.

18. Verfahren nach Anspruch 1, wobei das mindestens eine der Bits der mindestens einen Vorrichtung (12) anzeigt, dass sie eine Vorrichtung innerhalb einer spezifizierten Gruppe zur Teilnahme an dem Arbitrierungsschema ist.

19. Verfahren nach Anspruch 1, weiter umfassend, dass die mindestens eine Vorrichtung (12) basierend auf mindestens einem Bit des zweiten Befehls bestimmt, ob die mindestens eine Vorrichtung (12) ein Teilnehmer ist, der auf den zweiten Befehl antworten darf.

20. Verfahren nach Anspruch 1 oder Anspruch 19, weiter umfassend, dass die mindestens eine Vorrichtung (12) einen Identifikationscode zur Verwendung bei der eindeutigen Identifikation eines Objekts, an dem die Vorrichtung (12) befestigt ist, rückstreut.

21. Verfahren nach Anspruch 1 oder Anspruch 19, weiter umfassend, dass die mindestens eine Vorrichtung (12) einen Identifikationscode zur Verwendung bei der eindeutigen Identifikation der mindestens einen Vorrichtung (12) und damit eines Objekts, an dem die Vorrichtung (12) befestigt ist, rückstreut.

22. Verfahren nach Anspruch 1, weiter umfassend, dass die Abfragevorrichtung (26) den Zufallswert zurück zu der mindestens einen Vorrichtung (12) überträgt, um individuell auf die mindestens eine Vorrichtung (12) zuzugreifen.

23. Verfahren nach Anspruch 22, weiter umfassend, dass die mindestens eine Vorrichtung (12) einen Identifikationscode rückstreut, der verwendet werden kann, um die mindestens eine Vorrichtung (12) oder ein Objekt, an dem die mindestens eine Vorrichtung (12) befestigt ist, eindeutig zu identifizieren.

24. Verfahren nach Anspruch 1, wobei die mindestens eine Vorrichtung (12) imstande ist, Energie rückzustreuen, die von der Abfragevorrichtung (26) erzeugt wurde, und in der Rückstreuung Energieinformationen einzuschließen, die die Vorrichtung (12) eindeutig identifizieren, und das Verfahren weiter umfasst, die Vorrichtung (12) an ein Objekt zu befestigen.
25. Verfahren nach Anspruch 1, wobei die Abfragevorrichtung (26) weiter einen Befehl überträgt, der eine Maske umfasst, wobei die Maske eine Bitfolge umfasst, wobei die Bitfolge von der mindestens einen Vorrichtung (12) verwendet wird, um zu bestimmen, ob die Markierung für weitere Kommunikation ausgewählt ist.
26. Verfahren nach einem der vorstehenden Ansprüche, wobei das Arbitrierungsschema ein adaptives, segmentiertes Zufalls-Antikollisionsschema umfasst, wobei die Adaption umfasst, die zweite Zahl von Schlitten als verschieden von der ersten Zahl von Schlitten auszuwählen.
27. System zur Ermöglichung von drahtloser Kommunikation zwischen elektronischen Vorrichtungen und zur Identifikation von mindestens einer der Vorrichtungen in einer Umgebung, die mehrere Vorrichtungen enthält, umfassend:
eine Abfragevorrichtung (26), Schaltungen umfassend, die für Funkfrequenz-Übertragung und -Empfang angepasst sind, und eine Antenne (28) in Signalkommunikation mit den Schaltungen; und mindestens eine Funkfrequenzidentifikations-Vorrichtung (12); **dadurch gekennzeichnet, dass** die Abfragevorrichtung (26) und die mindestens eine Funkfrequenzvorrichtung (12) angepasst sind, um gemäß dem Verfahren eines beliebigen der vorstehenden Ansprüche zu kommunizieren.
28. System nach Anspruch 27, wobei die mindestens eine Vorrichtung (12) eine passive Funkfrequenzidentifikations-Vorrichtung (12) umfasst, die eine integrierte Schaltung (16) und eine Antenne (14) in Signalkommunikation mit der integrierten Schaltung umfasst, wobei die Vorrichtung (12) weiter einen Rückstreuender zum Rückstreuen von Energie, die von der Abfragevorrichtung (26) emittiert wurde, umfasst.
29. System nach Anspruch 28, wobei die mindestens eine Vorrichtung (12) eine planare Form umfasst und zumindest teilweise aus einem Kunststoff gebildet ist und konfiguriert ist, um an ein Objekt befestigt zu werden.

Revendications

1. Procédé pour une communication sans fil entre un interrogateur (26) et au moins un dispositif d'identification radiofréquence (12) pour identifier le dispositif d'identification radiofréquence (12) dans un environnement contenant de multiples dispositifs d'identification radiofréquence, comprenant:
la fourniture de l'au moins un dispositif (12), dans lequel l'au moins un dispositif (12) est configuré pour générer une valeur aléatoire pour une utilisation au niveau d'un schéma d'arbitrage;
l'envoi d'une première commande depuis l'interrogateur (26) jusqu'à l'au moins un dispositif (12), la première commande comprenant un jeu de bits, au moins l'un desdits bits indiquant que l'au moins un dispositif est sélectionné pour participer audit schéma d'arbitrage; et **caractérisé par**
l'utilisation, en tant que partie dudit schéma d'arbitrage, de l'une sélectionnée de façon aléatoire d'un premier nombre de fenêtres temporelles afin de déterminer au moins partiellement lorsque ledit au moins un dispositif (12) peut communiquer une première réponse à ladite première commande;
l'envoi d'une seconde commande depuis l'interrogateur (26) jusqu'à l'au moins un dispositif (12);
l'utilisation, en tant que partie dudit schéma d'arbitrage, de l'une sélectionnée de façon aléatoire d'un second nombre de fenêtres temporelles afin de déterminer au moins partiellement lorsque ledit au moins un dispositif peut communiquer une seconde réponse à ladite seconde commande, ledit second nombre de fenêtres temporelles étant différent dudit premier nombre de fenêtres temporelles; et
la communication de la seconde réponse depuis l'au moins un dispositif (12) à l'interrogateur (26), la seconde réponse comprenant ladite valeur aléatoire générée par le dispositif (12).
2. Procédé selon la revendication 1, comprenant en outre:
la communication de ladite première réponse depuis ledit au moins un dispositif (12); et
la détermination du fait que ladite première réponse entre en collision avec une autre communication,

dans lequel ladite seconde commande est envoyée en réponse audit acte de détermination.

3. Procédé selon la revendication 1, dans lequel ledit second nombre de fenêtres temporelles est inférieur audit premier nombre de fenêtres temporelles.

4. Procédé selon la revendication 3, comprenant en outre:

la délivrance, depuis ledit au moins un dispositif (12), de ladite première réponse;
la détection, en utilisant au moins ledit interrogateur (26), de lorsqu'une collision entre ladite première réponse et une autre communication s'est produite; et
la détermination dudit second nombre de fenêtres temporelles sur la base au moins en partie de ladite détection.

5. Procédé selon la revendication 4, comprenant en outre le fait que l'au moins un dispositif (12) rétrodiffuse au moins une partie d'un code d'identification qui identifie de façon unique un objet sur lequel l'au moins un dispositif (12) est fixé.

6. Procédé selon la revendication 1, dans lequel ladite valeur aléatoire comprend un nombre aléatoire de 16 bits.

7. Procédé selon la revendication 1, dans lequel ledit au moins un dispositif (12) choisit ladite valeur aléatoire indépendamment de valeurs aléatoires sélectionnées par d'autres dispositifs qui communiquent avec ledit interrogateur (26).

8. Procédé selon la revendication 1, dans lequel ledit procédé comprend en outre la communication de la première réponse en provenance de l'au moins un dispositif (12) à l'interrogateur (26), la première réponse comprenant une valeur d'identification unique associée à l'au moins un dispositif (12).

9. Procédé selon la revendication 1, comprenant en outre l'envoi d'un signal depuis l'interrogateur (26) sur l'au moins un dispositif (12) en réponse à la réception de la seconde réponse.

10. Procédé selon la revendication 9, dans lequel ledit signal comprend un accusé de réception pour la seconde réponse.

11. Procédé selon la revendication 1, dans lequel la seconde réponse est reçue par l'interrogateur (26) sans détecter une collision.

12. Procédé selon la revendication 1, dans lequel ladite seconde commande est délivrée par ledit interrogateur (26) essentiellement en réponse au fait que ledit interrogateur détermine qu'une collision s'est produite entre ladite première réponse et une communication d'un autre dispositif.

13. Procédé selon la revendication 1, dans lequel ladite utilisation de l'une sélectionnée de façon aléatoire d'un premier nombre de fenêtres temporelles afin de déterminer au moins partiellement lorsque ledit au moins un dispositif (12) peut communiquer une première réponse comprend la capture de ladite une sélectionnée de façon aléatoire dudit premier nombre de fenêtres temporelles en réponse à ladite première commande.

14. Procédé selon la revendication 13, dans lequel ladite utilisation de l'une sélectionnée de façon aléatoire d'un second nombre de fenêtres temporelles afin de déterminer au moins partiellement lorsque ledit au moins un dispositif (12) peut communiquer une seconde réponse comprend la capture de ladite une sélectionnée de façon aléatoire dudit second nombre de fenêtres temporelles en réponse à ladite seconde commande.

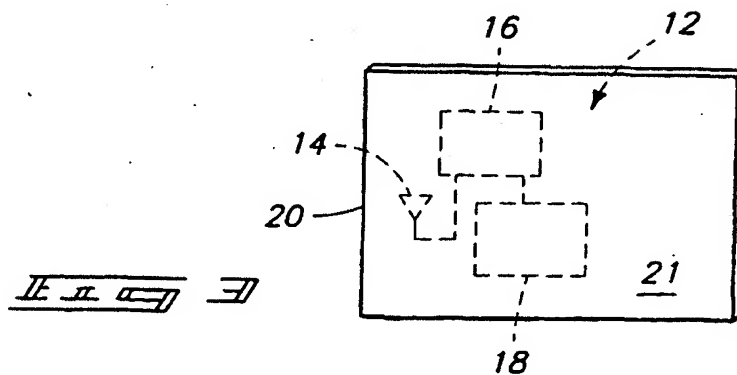
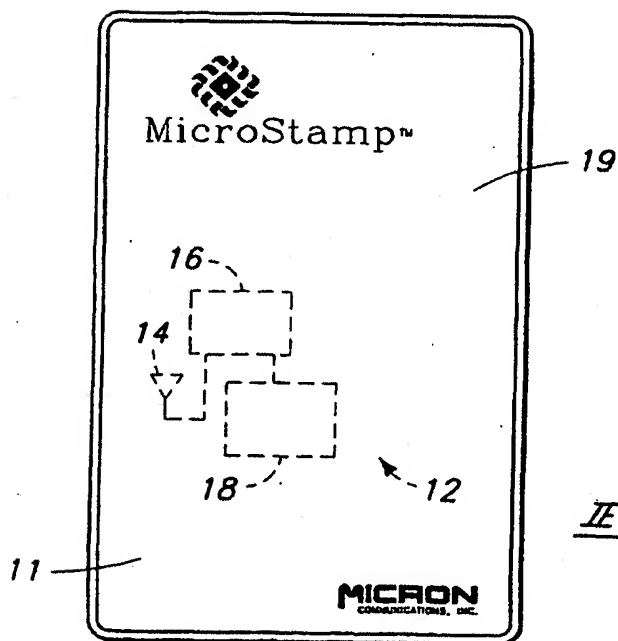
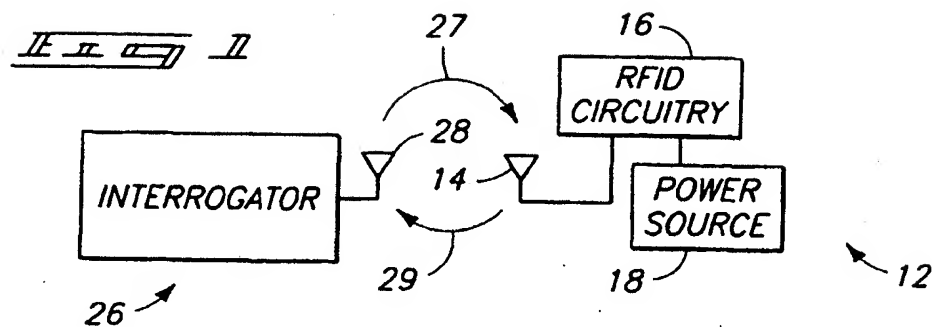
15. Procédé selon la revendication 14, dans lequel l'au moins un dispositif (12) comprend un dispositif d'identification radiofréquence (RFID) passif (12) adapté pour rétrodiffuser l'énergie transmise depuis ledit appareil d'interrogation, et en outre adapté pour être fixé sur un objet.

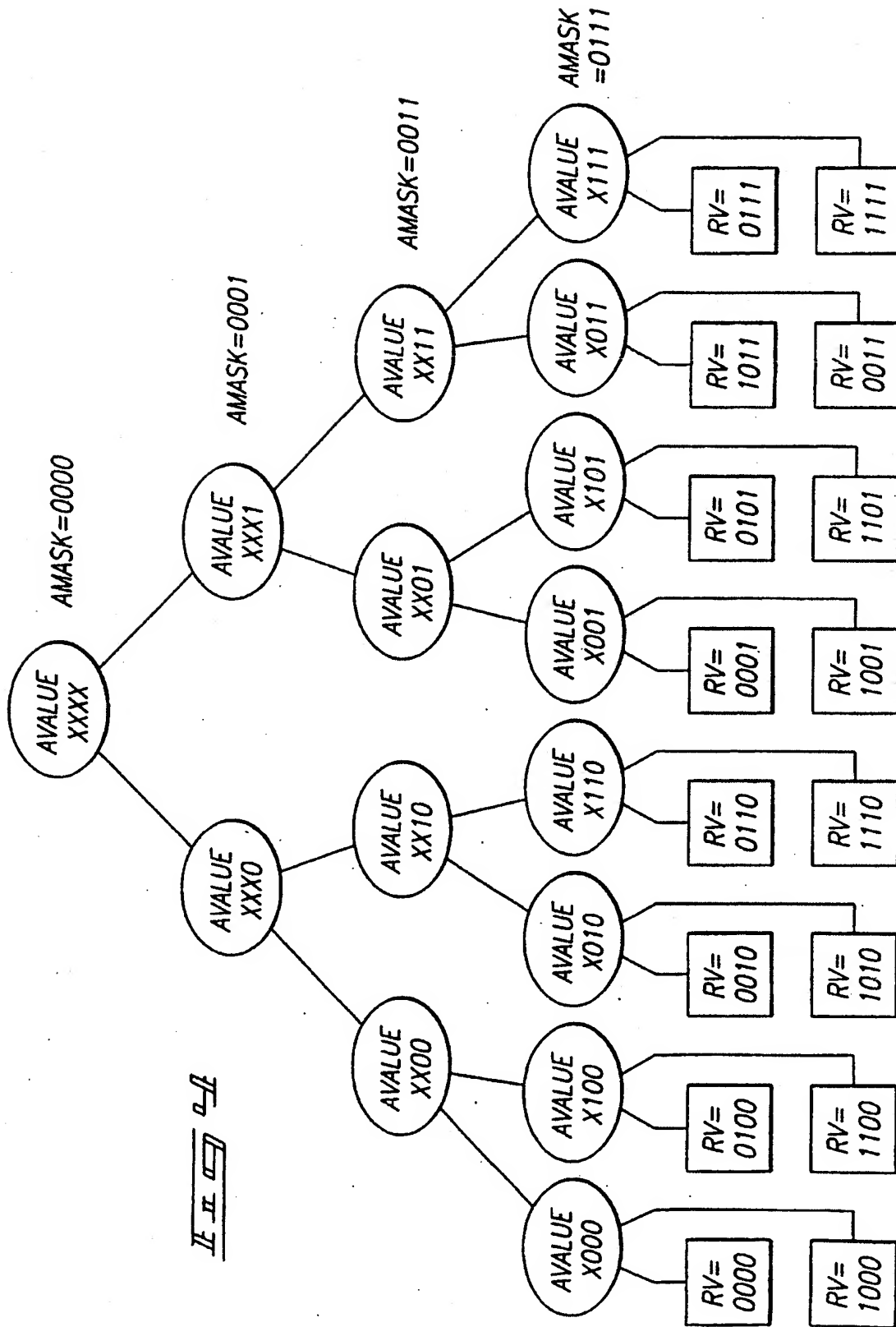
16. Procédé selon la revendication 1, dans lequel ledit au moins un dispositif (12) comprend une pluralité d'étiquettes d'identification radiofréquence, et ledit schéma d'arbitrage concerne la survenue de collisions de communication entre celles desdites étiquettes et dudit second nombre de fenêtres temporelles.

17. Procédé selon la revendication 1, dans lequel ladite première commande comprend une commande demandant qu'une pluralité de dispositifs incluant ledit au moins un dispositif (12) s'identifient eux-mêmes via ladite première

réponse.

18. Procédé selon la revendication 1, dans lequel ledit au moins un desdits bits indique à l'au moins un dispositif (12) qu'il s'agit d'un dispositif à l'intérieur d'un groupe spécifié pour une participation audit schéma d'arbitrage.
19. Procédé selon la revendication 1, comprenant en outre le fait que l'au moins un dispositif (12) détermine, sur la base d'au moins un bit de la seconde commande, si l'au moins un dispositif (12) est un participant qui peut répondre à la seconde commande.
20. Procédé selon la revendication 1 ou 19, comprenant en outre le fait que l'au moins un dispositif (12) rétrodiffuse un code d'identification pour une utilisation au niveau de l'identification de façon unique d'un objet sur lequel le dispositif (12) est fixé.
21. Procédé selon la revendication 1 ou 19, comprenant en outre le fait que l'au moins un dispositif (12) rétrodiffuse un code d'identification pour une utilisation au niveau de l'identification de façon unique dudit au moins un dispositif (12) et par conséquent, d'un objet sur lequel l'au moins un dispositif (12) est fixé.
22. Procédé selon la revendication 1, comprenant en outre le fait que l'interrogateur (26) transmet la valeur aléatoire en retour à l'au moins un dispositif (12) afin d'accéder de façon individuelle à l'au moins un dispositif (12).
23. Procédé selon la revendication 22, comprenant en outre le fait que l'au moins un dispositif (12) rétrodiffuse un code d'identification qui peut être utilisé pour identifier de façon unique ledit au moins un dispositif (12) ou un objet sur lequel l'au moins un dispositif (12) est fixé.
24. Procédé selon la revendication 1, dans lequel l'au moins un dispositif (12) peut rétrodiffuser l'énergie générée par ledit interrogateur (26) et peut inclure dans ladite énergie rétrodiffusée une information identifiant de façon unique ledit dispositif (12), et ledit procédé comprend en outre la fixation dudit dispositif (12) sur un objet.
25. Procédé selon la revendication 1, dans lequel ledit interrogateur (26) transmet en outre une commande comprenant un masque, ledit masque comprenant une chaîne de bits, ladite chaîne de bits étant utilisée par ledit au moins un dispositif (12) pour déterminer si ladite étiquette est sélectionnée pour une autre communication ou non.
26. Procédé selon l'une quelconque des revendications précédentes, dans lequel ledit schéma d'arbitrage comprend un schéma anti-collision aléatoire adaptatif en termes de fenêtres temporelles selon lequel ladite adaptation comprend la sélection du second nombre de fenêtres temporelles de telle sorte qu'il soit différent du premier nombre de fenêtres temporelles.
27. Système pour permettre une communication sans fil entre des dispositifs électroniques et pour identifier au moins l'un des dispositifs dans un environnement contenant de multiples dispositifs, comprenant:
 - un interrogateur (26) comprenant un circuit adapté pour une émission et une réception radiofréquence et une antenne (28) en communication de signal avec ledit circuit; et au moins un dispositif d'identification radiofréquence (12), **caractérisé en ce que** ledit interrogateur (26) et ledit au moins un dispositif radiofréquence (12) sont adaptés pour communiquer conformément au procédé selon l'une quelconque des revendications précédentes.
28. Système selon la revendication 27, dans lequel ledit au moins un dispositif (12) comprend un dispositif d'identification radiofréquence passif (12) comprenant un circuit intégré (16) et une antenne (14) en communication de signal avec ledit circuit intégré, ledit dispositif (12) comprenant en outre un émetteur de rétrodiffusion pour rétrodiffuser l'énergie émise par ledit interrogateur (26).
29. Système selon la revendication 28, dans lequel ledit au moins un dispositif (12) présente une forme plane et est formé au moins partiellement à partir d'une matière plastique, et est configuré de manière à être fixé sur un objet.





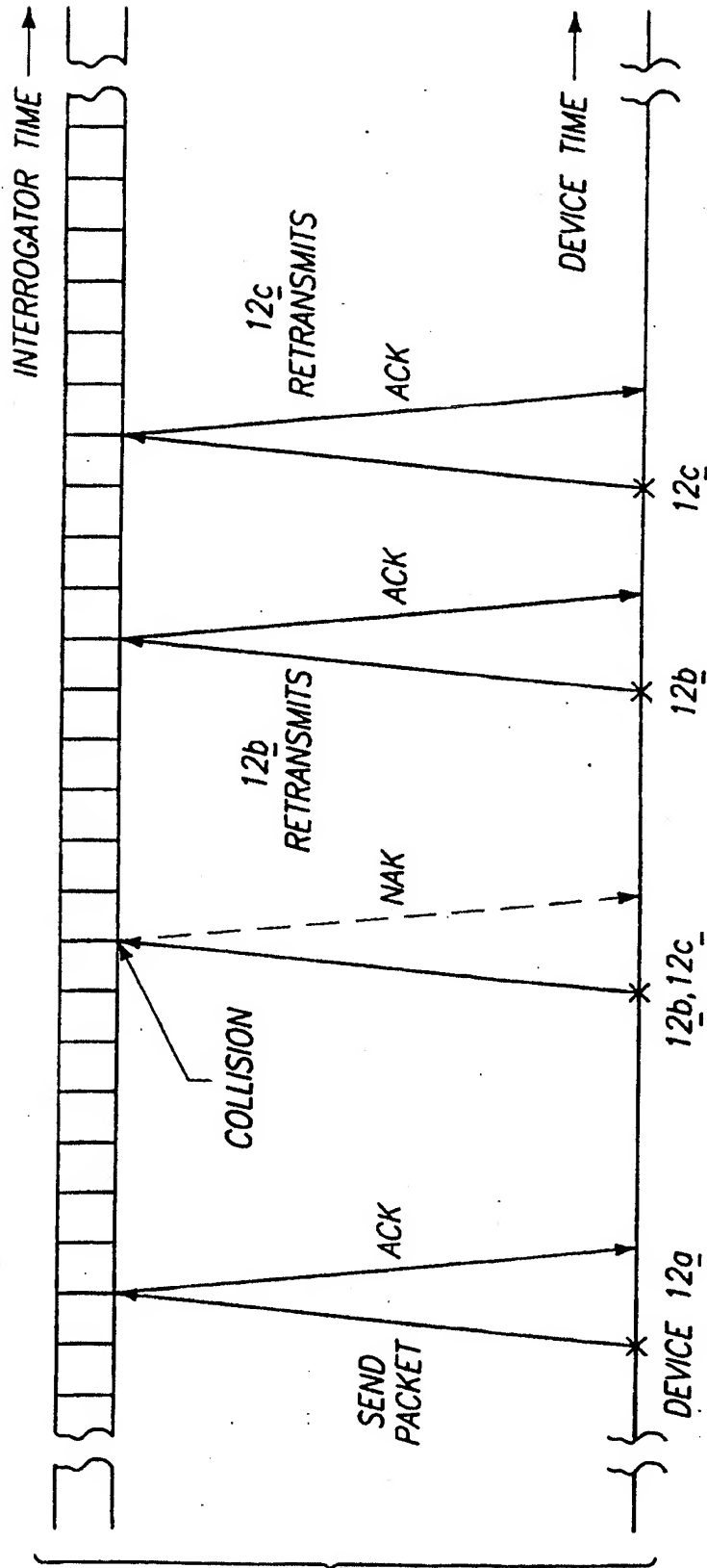
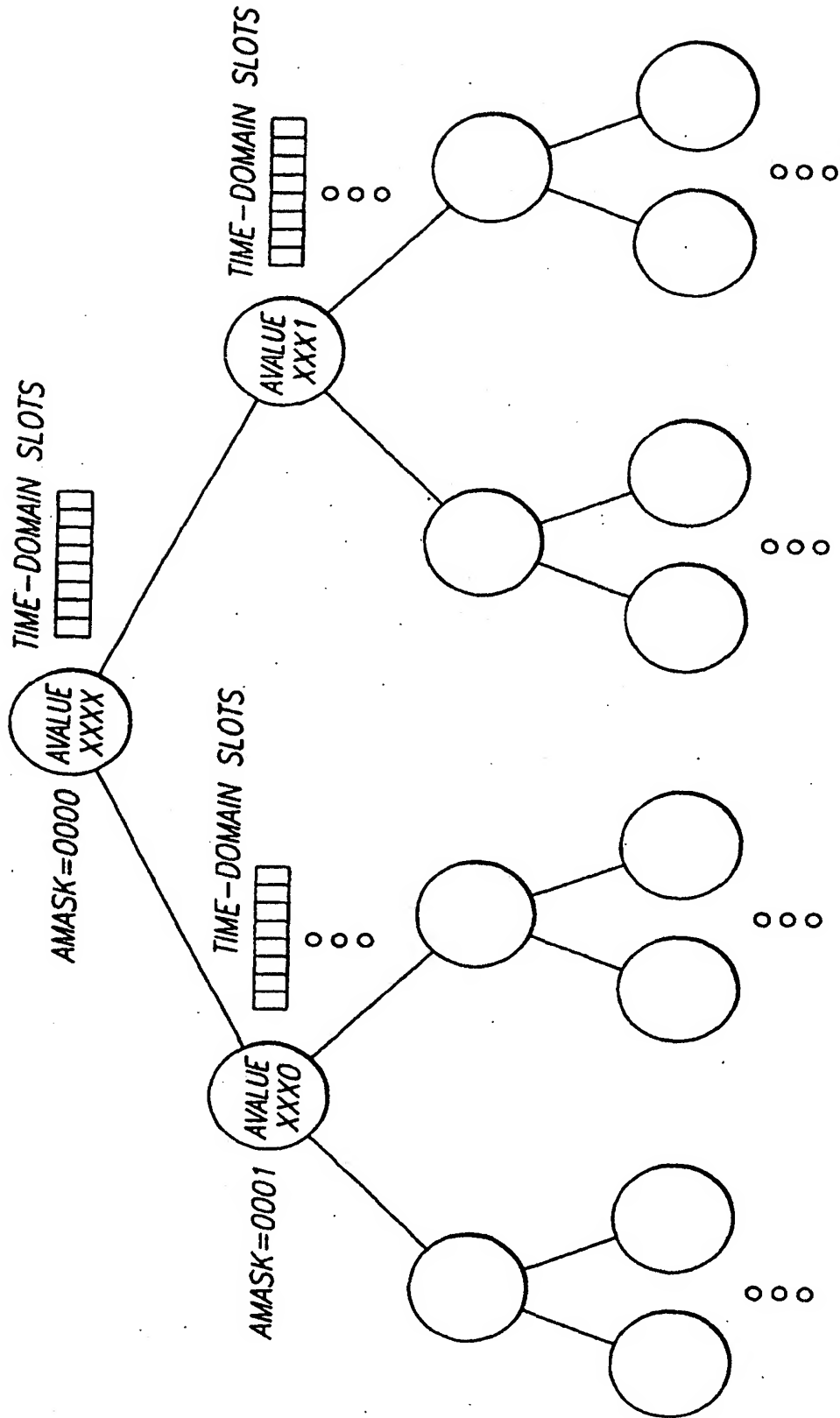


FIG. 5



Il x a 16

REFERENCES CITED IN THE DESCRIPTION

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